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Relationship Between Tissue Zinc Levels and Maturity Period of Field Beans¹

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ABSTRACT

The number of days from bean planting to harvest maturity is related to the zinc concentration of either leaf tissue or total top at or prior to bloom stage. In two geographical areas and with two bean varieties, optimum maturity period was associated with approximately 20 ppm or more zinc in these tissues. Below 20 ppm, the number of days required to reach maturity increases rapidly. With zinc levels below 15 ppm there was an increase of up to 30 days in the time required to reach maturity.

Additional index words: None.

MOST bean varieties (*Phaseolus vulgaris*) are susceptible to zinc deficiency and, if grown where zinc deficiency occurs, are invariably listed among those crops with the greatest need for zinc fertilization (1, 2, 3, 4). Bean plants with mild to moderate zinc-deficiency symptoms early in the growing season may recover and produce essentially a normal yield. However, as several individuals have observed (1, 2, 3) this early-season zinc deficiency invariably results in delayed maturity. This is a critical factor in geographical areas where beans may be damaged by fall rains or early frost.

The research reported here establishes quantitative relationships between the zinc level in bean tissues and the number of days required for maturation. The results support previous observations of delayed maturity when bean plants have inadequate zinc during early growth.

PROCEDURE

Kimberly, Idaho

Sanilac beans were grown on Portneuf silt loam in a zinc fertility experiment. Because of differences in chemical properties and particle sizes of the zinc fertilizers, the plants growing on the various plots were subject to a wide range of zinc nutrition. Beans were planted on May 25 and the earliest plots were at harvest maturity on August 28 (95 days). Following this date maturity evaluations were made daily until the most retarded plot was judged mature on September 13 (121 days). Plots were judged to have reached harvest maturity when approximately 80 per cent of the pods were ripe or showing "buckskin" coloration.

Zinc status of plants in each plot was based on total tops sampled 50 days after planting. The sample consisted of 10 plants selected at random.

Othello, Washington

Red Mexican beans (Big Bend) were grown on zinc-deficient Shano silt loam in two experiments, one in 1966 and another in 1967. Because of variations in zinc fertilizer source, particle size, and zinc rate, the plants on the various treatments displayed a wide range in zinc-deficiency symptoms, ranging from none to stunting so severe that no yield was obtained. The criterion for judging harvest maturity was the same as at Kimberly, Idaho.

In 1966, beans were planted on May 23 and the earliest maturity date was September 9 (109 days). Other plots in this

experiment required 121 days and 134 days to reach maturity. The plants on one treatment were still immature after 134 days. Evaluation of zinc status was based on total tops sampled 58 days after planting (early bloom stage of non-deficient plants). The sample consisted of 15 plants taken at random.

In 1967, beans were planted on May 18 and the earliest maturity date was August 25 (100 days). Additional maturity evaluations were made at 4-day intervals until 128 days had elapsed. One set of plots was immature after 128 days. Plant tissue samples for zinc assay were taken 30 days after planting (four-compound-leaf stage) and 61 days after planting (full bloom stage). The early sampling consisted of 20 total tops taken at random. Both leaves and total tops were sampled at full bloom. The leaf sample was 30 leaflets from the youngest, fully mature leaves and the total top sample was 10 plants from the same row area.

Zinc analyses were made by atomic absorption spectrophotometry on samples dried at 65 C and digested with nitric and perchloric acids.

RESULTS

The relationship between tissue zinc levels of Sanilac beans grown at Kimberly, Idaho, and the number of days required to reach harvest maturity is shown in Figure 1. These data show that maturity was delayed if the zinc concentration of plant tops was below approximately 18 ppm at bloom stage. On the other hand, increasing the zinc level to 30 ppm did not decrease the maturity period. With less than 18 ppm zinc the maturity period increased abruptly and required 120 days when the zinc level was 11 to 12 ppm.

Table 1 shows zinc concentrations and maturity periods for Red Mexican beans grown at Othello, Wash. in 1966 with zinc nutritional levels that resulted in maturity periods ranging from 109 to more than 134 days. These data show an extended maturity period when the zinc concentration in plant tops at

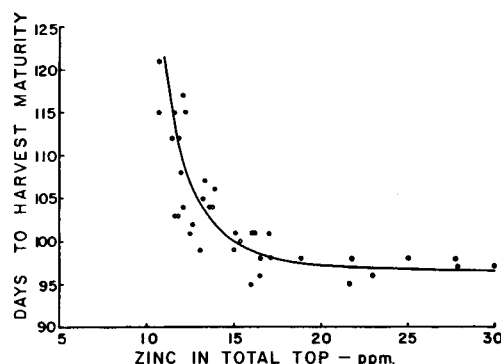


Fig. 1. Relationship between zinc concentration in total tops of Sanilac beans 50 days after planting and the number of days to harvest maturity (Kimberly, Idaho). Eye-fitted curve shown.

Table 1. Zinc concentration in total top of Red Mexican beans at early bloom and days to harvest maturity (Othello, Wash.).

Number of observations	Zinc conc., ppm		Days to harvest maturity
	Range	Mean	
36	20-36	27.4	109
4	20-24	22.0	121
8	14-17	15.8	134
4	12-15	13.2	>134

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early bloom was 22 ppm or less. Again, levels of zinc as high as 36 ppm did not shorten maturity period. Below 22 ppm the number of days to maturity increased rapidly and plants that averaged 13 ppm zinc were still immature after 134 days.

Figures 2 and 3 show the relationship between zinc in total tops at four-compound-leaf stage and at full bloom and the number of days to harvest maturity for Red Mexican beans grown at Othello in 1967. From Fig. 2 it is again evident that maturity date was delayed if plant top zinc at the four-compound-leaf stage was below approximately 25 ppm. With lesser amounts of zinc at this stage of growth the number of days

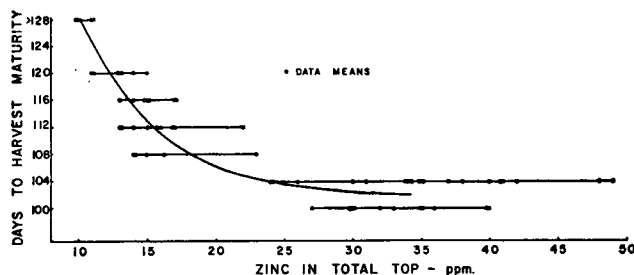


Fig. 2. Relationship between zinc concentration in total top of Red Mexican beans at four-compound-leaf stage and the number of days to harvest maturity (Othello, Wash.). Eye-fitted curve shown.

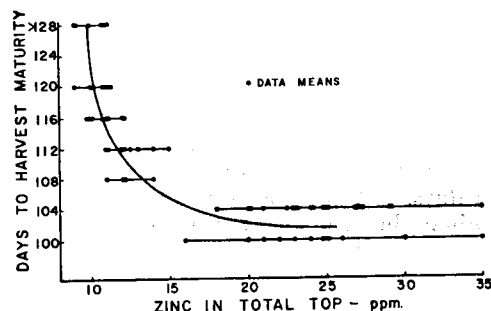


Fig. 3. Relationship between zinc concentration in total tops of Red Mexican beans at full bloom stage and the number of days to harvest maturity (Othello, Wash.). Eye-fitted curve shown.

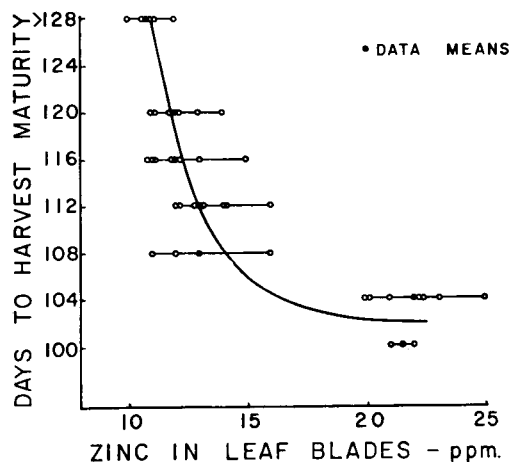


Fig. 4. Relationship between zinc concentration in mature leaf blades of Red Mexican beans at full bloom stage and the number of days to harvest maturity (Othello, Wash.). Eye-fitted curve shown.

to maturity increased rapidly and with 11 ppm zinc maturity had not been reached after 128 days. Optimum maturity was associated with a somewhat lower level of zinc in plant tops at the full bloom period, about 18 ppm (Fig. 3). Again, lower levels of zinc were associated with marked increases in the number of days to maturity, with maturity exceeding 128 days when zinc concentration was 10 ppm.

The relationship between zinc concentration in leaf blades at full bloom and maturity period is shown in Fig. 4. The optimum maturity period of 100 to 104 days was associated with 20 ppm or more zinc. With less than 20 ppm zinc in leaf blades at this stage of growth maturity was delayed and exceeded 128 days when the zinc level was about 12 ppm.

DISCUSSION

The relationships between tissue zinc levels and maturity period of beans presented here substantiate the repeated observation that zinc deficiency markedly delays the maturity of field beans. LeBaron's (2) observation that maturity may be delayed 10-14 days is conservative. In the experiments reported, a 3-week increase in the growing period occurred when plants showed only moderate zinc-deficiency symptoms. When there is a severe deficiency, a 30-day extension of the growing period can be expected. Since previous research has indicated that definite symptoms of zinc deficiency may not appear until plants have as little as 15 ppm zinc in tops or leaf tissue (5), it seems likely from the relationships presented that maturity may be delayed considerably even without visual evidence of zinc-deficiency symptoms.

Zinc deficiency commonly develops in irregular patches within a field. Thus, another ramification of zinc deficiency in beans is the variability in ripening, making it impossible to harvest the entire crop at optimum maturity. Aside from the obvious loss in terms of total yield, the inclusion of immature beans lowers the market grade.

The analytical values for adequate and inadequate levels of zinc established by these studies agree remarkably well with the earlier work of Viets et al. (5). Also, their observation that leaf tissue or total tops serve equally well as diagnostic tissue is upheld. Further confidence in tissue analysis as a guide to the zinc nutritional status of beans is given by the remarkably consistent results obtained under variable conditions of soil, climate, and growing season.

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